METRIC

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31 July 1994
SUPERSEDING
MIL-HDBK-263A
22 February 1991
(See 6.1 and 6.4)

MILITARY HANDBOOK

ELECTROSTATIC DISCHARGE CONTROL HANDBOOK FOR PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES AND EQUIPMENT (EXCLUDING ELECTRICALLY INITIATED EXPLOSIVE DEVICES) (METRIC)

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FOREWORD

1. This military handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 91Q22, 2531 Jefferson Davis Highway, Arlington, Virginia 22242-5160, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

3. This handbook provides guidance, not mandatory requirements, for the establishment and implementation of an Electrostatic Discharge (ESD) Control Program in accordance with the requirements of MIL-STD-1686. This document is applicable to the protection of electrical and electronic parts, assemblies and equipment from damage due to ESD. It does not provide information for the protection of electrically initiated explosive devices.

4. Various segments of industry are aware of the damage static electricity can impose on metal oxide semiconductor (MOS) parts. The sensitivity of other parts to electrostatic discharge damage has also become evident through use, testing, and failure analysis. Trends in technology utilizing new materials, processes and design techniques, including increased packaging densities result in some parts being more susceptible to ESD.

5. Electrical and electronic parts which have been determined to be ESD sensitive (ESDS) include: microelectronic discrete and integrated semiconductor devices; thick and thin film resistors, chips and hybrid devices; and piezoelectric crystals. Subassemblies, assemblies and equipment containing these parts are also ESDS.

6. Materials which are prime generators of electrostatic voltages include, but are not limited to, common plastics such as polyethylene, vinyls, foam, polyurethane, synthetic textiles, fiberglass, glass, rubber, and other commonly used materials. Damaging electrostatic voltage levels are commonly generated by contact and subsequent separation of these materials by industrial processes and personnel movement.

7. Intense pressure has existed, and continues to exist, for a "cook book" approach to ESD control program implementation. Simplistic approaches to a complex technical subject such as electrostatic discharge control program design and implementation are neither desirable, cost effective nor feasible. A single "cook book" ESD control program cannot be mandated or prepared which is applicable for all situations. An "idealized" ESD control program may represent overkill for most applications. In contrast, a less rigorous

program may not offer sufficient or adequate protection in all situations. Therefore, an ESD control program must be custom-tailored to meet the specific requirements of the preparer for their specific product in its unique manufacturing facility and expected environments. The ESD control program plan (data item description (DID) DI-RELI-80669A) is developed to establish efficient and cost effective ESD controls and procedures. The ESD control program plan provides the opportunity to tailor the technical approach for implementation of ESD controls in a meaningful and cost effective manner.

8. The protection of ESDS parts, subassemblies, assemblies and equipment *will be provided through the implementation of cost effective ESD controls.* The lack of implementation of ESD controls and procedures throughout the equipment life-time has resulted in increased repair costs, equipment downtime, and reduced mission readiness.

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1. SCOPE

1.1 Scope. This handbook provides guidance for developing, implementing and monitoring an ESD control program in accordance with the requirements of MIL-STD-1686. Information is provided in 6.1 that cross references the various revisions of MIL-HDBK-263 to the appropriate revision of MIL-STD-1686. This handbook is not applicable to electrically initiated explosive devices. The specific guidance provided is supplemented by the technical data contained in the appendices. Table I provides a cross-reference listing of MIL-STD-1686 requirements, MIL-HDBK-263 guidance, and MIL-HDBK-263 supplementary technical data.

TABLE I. Cross-reference table.

MIL-STD-1686B Requirement section	MIL-HDBK-263B Guidance section	MIL-HDBK-263B Supplementary technical data appendix
1.3	1.2	--
1.3.1	1.2.1, 1.3	--
1.3.1.1	1.3	--
4.1	4.1	--
4.2	1.3.2, 5.1, 5.5	--
5.1	5.1	--
5.1.1	5.1	--
5.2	5.2	B, D
5.2.1.1	5.2.1	B, D
5.2.1.2	5.2.2	D
5.3	5.3	E
5.3.1	5.3.1	E
5.3.2	5.3.2	E
5.4	5.4	F, G, H, I

TABLE I. Cross-reference table - Continued.

MIL-STD-1686B Requirement section	MIL-HDBK-263B Guidance section	MIL-HDBK-263B Supplementary technical data appendix
5.5	5.5	H
5.5.1	5.5	H
5.6	5.6	I
5.7	5.7	J
5.8	5.8	--
5.8.1	5.8	--
5.8.2	5.8.1	--
5.8.3	5.8.2	--
5.8.3.1	5.8.3	--
5.9	5.9	--
5.9.1	5.9	--
5.9.2	5.9	--
5.10	5.10	I
5.11	5.11	H, K
5.11.1	5.11	H, K
5.11.2	5.11	H, K
5.12	5.12	H, K
5.12.1	5.12	E, F
5.12.2	5.12	E, F
5.13	5.13	B, C

1.2 Application of MIL-STD-1686. The application of MIL-STD-1686 requirements will result in continuous ESD controls throughout the life-time of ESD susceptible parts, assemblies, and equipment. For this reason, MIL-STD-1686 requirements will be applied to Government and contractor activities including subcontractors, suppliers, and vendors. The term "contractor" in MIL-STD-1686 will be replaced with "Government activity" as appropriate when the requirements are applied to the Government.

1.2.1 MIL-STD-1686 application considerations. Effective application of MIL-STD-1686 requirements mandates careful consideration of the technical and cost impacts associated with each acquisition type. Proper application of MIL-STD-1686 requirements must address three considerations: tailoring, mission critical or essential equipment, and reacquisition requirements. Each of these considerations is related. Tailoring of MIL-STD-1686 is directly related to the work efforts to be performed. As an example, an acquisition that is initiated for new design hardware items should incorporate all elements required by MIL-STD-1686 (see table I of MIL-STD-1686). In contrast to this, reacquisition of hardware items not previously subject to an ESD control program should delete the MIL-STD-1686 requirement for design protection. Redesign of hardware for reacquisitions is generally not cost effective. This also applies in the case of Government acquisition of non-developmental items (NDI) or commercial off-the-shelf (COTS) electronic equipment. In these cases, redesign of NDI or COTS electronic equipment to conform to MIL-STD-1686 design hardening requirements (if invoked) would negate the cost benefits of NDI/COTS acquisition. Closely related to these topics is the inclusion of class 3 parts, assemblies, and equipment in the ESD control program. This aspect of ESD control is solely at the discretion of the acquiring activity and should be invoked only for equipment designated by the acquiring activity as mission critical or essential.

1.3 Tailoring of MIL-STD-1686. MIL-STD-1686, as discussed above, is applied to both Government and contractors to ensure ESD controls are continuously provided throughout the life-time of ESD susceptible parts, assemblies, and equipment. When MIL-STD-1686 is contractually invoked the initial step that should be performed by the contractor is a contract review to determine if any part of the acquisition has been designated as mission critical or essential equipment by the acquiring activity. If this has been done, MIL-STD-1686, 1.3.1.1 requires that the ESD control program encompasses not only Class 1 and Class 2 parts, assemblies and equipment but be expanded to also include Class 3 items. This is a first step in the tailoring of MIL-STD-1686.

1.3.1 Contractual review. The second step performed by the contractor in tailoring MIL-STD-1686 should be the completion of a review to determine the exact ESD control program requirements invoked in the contract. MIL-STD-1686, 1.3.1 states "The contractor shall tailor the ESD control program for the acquisition by selecting the applicable functions and elements of Table I." This requirement does not preclude or limit Government tailoring or

modification of MIL-STD-1686 for a specific acquisition. Contractor review of the contractual document is critical to determining contractual requirements, compliance with contractual requirements and tailoring of MIL-STD-1686 by the contractor. Tailoring of MIL-STD-1686 must always be accomplished in accordance with the contractual requirements.

1.3.2 Deliverable data requirements. The review of the contract or purchase order will also provide a determination of Government Data Requirements (see MIL-STD-1686, 6.2) for the acquisition. When the contract or purchase order requires that an Electrostatic Discharge Control Program Plan be developed and delivered, MIL-STD-1686, 1.3.1 requires that tailoring rationale and data be included in the Plan. Contractor tailoring of MIL-STD-1686 is subject to approval by the acquiring activity and is normally accomplished by formal Government acceptance or rejection of the plan.

1.3.3 Tailoring flow chart. To facilitate the understanding of the MIL-STD-1686 tailoring process Figure 1 graphically depicts the process as discussed above and in MIL-STD-1686, 1.3.1. The reference numbers in the Figure 1 flow chart blocks are the MIL-STD-1686 requirements paragraphs and are included for ready reference. Figure 1 cannot, and does not take precedence over contractual, delivery order or MIL-STD-1686 requirements.

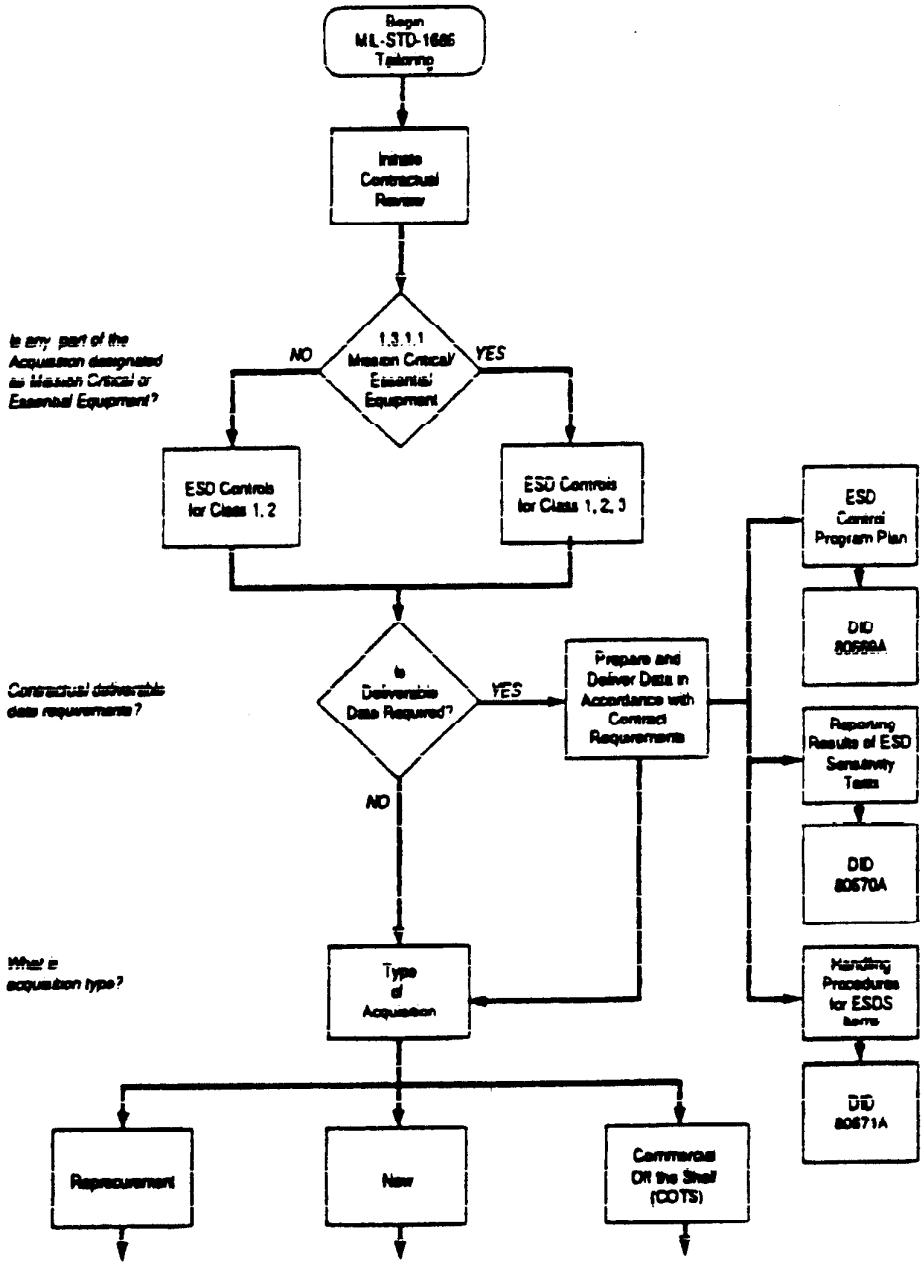

FIGURE 1. MIL-STD-1686 tailoring.

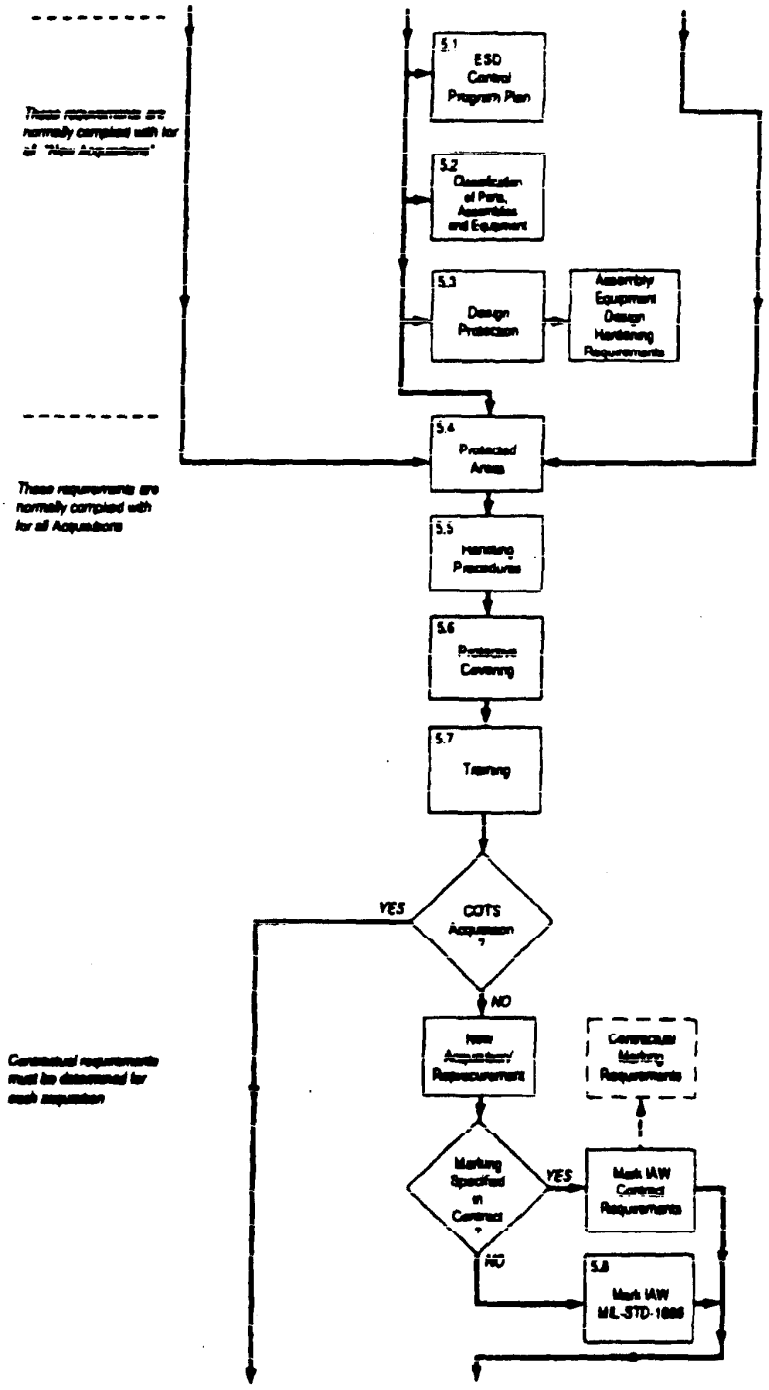

FIGURE 1. MIL-STD-1686 tailoring - Continued.

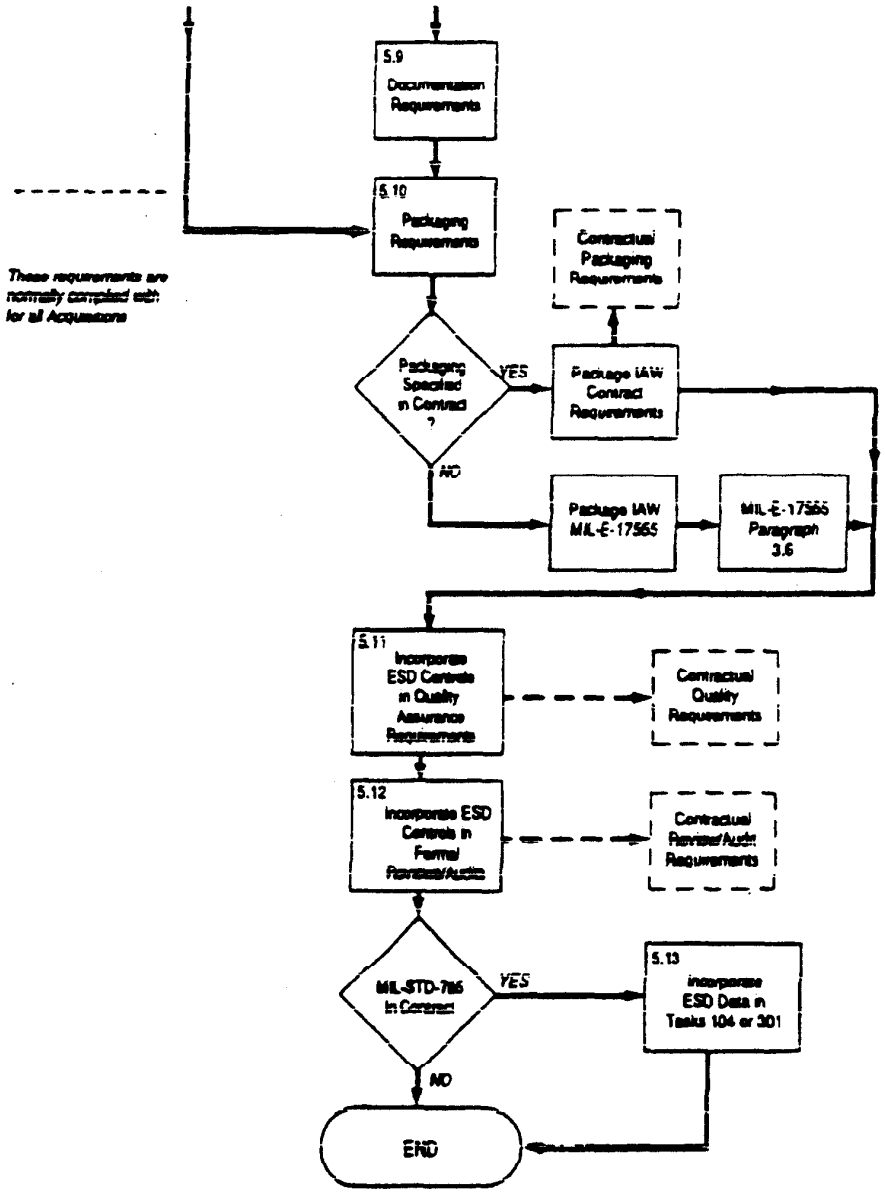

FIGURE 1. MIL-STD-1686 tailoring - Continued.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, handbooks, and bulletins. The following specifications, standards, handbooks, and bulletins form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

MILITARY

MIL-E-17555	-	Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of.
MIL-S-19500	-	Semiconductor Devices, General Specification for.
MIL-T-31000	-	Technical Data Packages, General Specification for.
MIL-M-38510	-	Microcircuits, General Specification for.
MIL-H-38534	-	Hybrid Microcircuits, General Specification for.
MIL-I-38535	-	Integrated Circuits (Microcircuits) Manufacturing, General Specification for.
MIL-T-47500	-	Technical Data Packages.

STANDARDS

MILITARY

DOD-STD-100	-	Engineering Drawing Practices.
MIL-STD-454	-	Standard General Requirements for Electronic Equipment.
MIL-STD-750	-	Test Methods for Semiconductor Devices.
MIL-STD-785	-	Reliability Program for Systems and Equipment Development and Production.
MIL-STD-883	-	Test Methods and Procedures for Microelectronics.
MIL-STD-1521	-	Technical Reviews and Audits for Systems, Equipments, and Computer Programs.
MIL-STD-1686	-	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices). (Metric)

MIL-STD-2073-1 - DOD Materiel Procedures for Development and Application of Packaging Requirements.
MIL-STD-2073-2 - Packaging Requirement Codes.

BULLETINS

MILITARY
MIL-BUL-103 - List of Standardized Military Drawings (SMDs)

(Unless otherwise indicated, copies of federal and military specifications, standards, handbooks, and bulletins are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

ELECTRONIC INDUSTRIES ASSOCIATION STANDARD
RS-471 - Symbol and Label for Electrostatic Sensitive Devices.

(Application for copies should be addressed to the Electronic Industries Association, Engineering Department, 2001 Eye Street, NW, Washington, DC 20006.)

RELIABILITY ANALYSIS CENTER (RAC)
VZAP-91- Electrostatic Discharge Susceptibility Data 1991

(Application for copies should be addressed to the Reliability Analysis Center, P.O. Box 4700, Rome, NY 13440-8200.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Definitions. The following definitions apply to MIL-STD-1686 requirements and MIL-HDBK-263 guidance.

3.2 Accelerated life testing. A test under which test conditions are more severe than specified operating conditions.

3.3 Antistatic property. This term refers to the reduction of triboelectric charge generation. Antistatic materials minimize the generation of static charges. This property is not dependent upon material resistivity.

3.4 Assembly. A number of parts or subassemblies or any combination thereof joined together to perform a specific function and capable of disassembly.

3.5 Avalanche breakdown. A breakdown caused by the cumulative multiplication of charge carriers through field-induced impact ionization.

3.6 Bulk breakdown. An energy dependent failure mechanism where changes in parameters result from metallization alloying or impurity diffusion due to localized high temperatures.

3.7 Catastrophic failure. A failure resulting in the permanent loss of a critical function.

3.8 Charge. The product of capacitance times voltage. Q (charge) = C (capacitance) x V (voltage).

3.9 Charged device model. A model characterizing a particular ESD failure mechanism in which an item isolated from ground is charged and is subsequently discharged causing a short duration discharge pulse.

3.10 Classification of ESDS parts, assemblies and equipment. Classification of ESDS parts, assemblies, and equipment that are susceptible to ESD voltages as defined by MIL-STD-1686. ESDS susceptibility voltages are classified as:

Class 1: Susceptible to damage from ESD voltages greater than 0 to 1,999 volts.

Class 2: Susceptible to damage from ESD voltages of 2,000 to 3,999 volts.

Class 3: Susceptible to damage from ESD voltages of 4,000 to 15,999 volts.

NOTE: For the purpose of MIL-STD-1686, parts, assemblies and equipment susceptible to ESD voltages of 16,000 volts or higher are considered non-ESD sensitive.

3.11 Classification testing. The testing procedures used to determine the ESD susceptibility class of parts. This procedure is described in MIL-STD-1686, appendix A.

3.12 Conductive material. For the purpose of ESD protection, material with the following characteristics:

Surface conductive type:	Materials with a surface resistivity less than 10^5 ohms per square.
Volume conductive type:	Materials with a volume resistivity less than 10^4 ohm-centimeter.

3.13 Corona discharge. A luminous discharge due to ionization of the air around a conductor.

3.14 Decay time. The time required for a voltage to be reduced to a given percentage of the initial voltage.

3.15 Device. An individual part such as a microcircuit or semiconductor device.

3.16 Dielectric breakdown. The failure of a dielectric material due to excessive voltage.

3.17 Dissipative material. For the purpose of ESD protection, material with the following characteristics:

Surface conductive type:	Materials with a surface resistivity equal to or greater than 10^5 but less than 10^{12} ohms per square.
Volume conductive type:	Materials with a volume resistivity equal to or greater than 10^4 but less than 10^{11} ohm-cm.

3.18 Earth ground. That portion of an electrical circuit that is at zero potential with respect to earth. (See ground.)

3.19 Electric field. The region surrounding an electrically charged object in which another electrical charge will experience force. Commonly referred to as an electrostatic field.

3.20 Electrical and electronic part. A part such as a microcircuit, discrete semiconductor, resistor, capacitor, or piezoelectric crystal.

3.21 Electrostatic charge. Electrical charge at rest. The negative or positive charge present on the material or item surface. (See charge.)

3.22 Electrostatic discharge (ESD). A transfer of electrostatic charge between objects at different potentials caused by direct contact or induced by an electrostatic field.

3.23 Electrostatic discharge sensitive (ESDS). The relative tendency of a device's performance to be affected or damaged by an ESD event.

3.24 Electrostatic field. A voltage gradient between electrostatically charged surfaces. (See electric field.)

3.25 Electrostatic shield. A barrier or enclosure that prevents or attenuates the penetration of an electric field.

3.26 Electrostatics. That class of phenomena which is recognized by the presence of electrical charges, either stationary or moving, and the interactions of these charges, this interaction being solely by reason of the charges themselves and their position and not by reason of their motion. (Ref: Electrostatics and Its Applications, A.D. Moore, Editor.)

3.27 Equipment. An assembly or any combination of parts, subassemblies and assemblies mounted together, normally capable of independent operation in a variety of situations.

3.28 ESD protected area. An area which is constructed and equipped with the necessary ESD protective materials, equipment, and procedures to limit ESD voltages below the sensitivity level of ESDS items handled therein.

3.29 ESD protective handling. Handling material and equipment in a manner to prevent damage from ESD.

3.30 ESD protective material. Material with one or more of the following properties: limits the generation of electrostatic charge; dissipates electrostatic charge; or provides shielding from electric fields. For the purpose of this handbook, ESD protective materials are classified as conductive or dissipative.

3.31 ESD protective packaging. Packaging with ESD protective materials to prevent ESD damage to ESDS items.

3.32 ESD sensitivity (ESDS) classification. Classification of the sensitivity of electronic parts, assemblies, and equipment based on their susceptibility to damage from electrostatic discharge.

3.33 Field induced model. A model characterizing an electrically floating device which is subjected to an electrostatic field and then is contacted to an object causing an ESD.

3.34 Ground. A mass such as the earth, or a ship or vehicle hull, capable of supplying or accepting electrical charge.

3.35 Handled or handling. Actions during which items are hand manipulated or machine processed.

3.36 Hard ground. A connection directly to earth ground.

3.37 Human body model. A standardized test model, characterized by the use of a 1,500 ohm resistor and a 100 picofarad capacitor.

3.38 Induction. The process by which an electrical charge establishes a charge in a nearby object without physical contact.

3.39 Input protection. A protective network at the input pins of an item to prevent electrical damage.

3.40 Insulative material. For the purpose of ESD protection, materials not defined as conductive or dissipative are considered to be insulative.

3.41 LRU. Line or lowest replaceable unit (electrical/electronic assembly or subassembly).

3.42 Part. One piece, or two or more pieces joined together which are not normally subject to disassembly without destruction of designed use. Parts, components, and devices are synonymous.

3.43 Protected area. See ESD protected area.

3.44 Protective handling. The special handling that is given to ESDS items in order to prevent ESD damage.

3.45 Protective packaging. Packaging with ESD protective materials to prevent electrostatic damage to ESDS items.

3.46 Protective storage. Storage of ESDS items while enclosed in ESD protective covering or packaging.

3.47 Resistivity. A measure of the resistance of a material to electric current either through its volume or on its surface. Surface resistivity is the ratio of direct current (dc) voltage to the current that passes across the surface of a material. The unit measurement for surface resistivity (ρs) is ohms per square. Volume resistivity is the ratio of dc voltage per unit of thickness applied across two electrodes in contact with a specimen to the amount of current per unit area passing through the material. The unit of measurement for volume resistivity (ρv) is ohm-centimeter.

3.48 Soft ground. A connection to ground through a resistance sufficient to limit current flow to safe levels for personnel.

3.49 SRU. System or shop replaceable unit (electrical/electronic subassemblies-usually a part of an LRU).

3.50 Static shielding materials. Material that attenuates an ESD.

3.51 Subassembly. Two or more parts which form a portion of an assembly or a unit replaceable as a whole, but having a part or parts which are individually replaceable.

3.52 Tailoring. As used herein, tailoring is the process by which individual requirements for a comprehensive ESD control program are evaluated to determine the extent to which they are applicable for a specific acquisition.

3.53 Technical data. As used herein, technical data means recorded information (regardless of the form or the method of the recording) of a scientific or technical nature used in a specific acquisition.

3.54 Technical data package (TDP). A TDP consists of a technical description of an item adequate for supporting an acquisition strategy, design, production, engineering, and logistic support. The TDP includes all applicable technical data such as drawings, associated lists, specifications, standards, performance requirements, quality assurance provisions, packaging and handling details.

3.55 Triboelectric effect. The generation of electrostatic charge on an object by rubbing or other type of contact.

4. GENERAL REQUIREMENTS OF MIL-STD-1686

4.1 General. The primary objective of ESD control program implementation is to provide continuous ESD protection. Life-time electrostatic control and protection entails implementation of ESD control program requirements (see ESD control program requirements table of MIL-STD-1686) during design, production, inspection, test, storage, shipment, installation, maintenance and repair functions. MIL-STD-1686 requirements, as tailored by the contractor (see MIL-

STD-1686, 1.3.1) and approved by the acquiring activity will define the ESD control program requirements for specific programs or products. Table I provides a cross-reference listing between the requirements sections of MIL-STD-1686, the guidance sections of MIL-HDBK-263, and the supplementary technical data appendices of MIL-HDBK-263.

5. DETAILED REQUIREMENTS OF MIL-STD-1686

5.1 ESD control program plan. The ESD control program plan provides the data required in accordance with MIL-STD-1686 and Data Item Description (DID) DI-RELI-80669A when required by the contract or purchase order (see MIL-STD-1686, 6.2). The approved ESD control program plan is the basis for comprehensive ESD controls and program implementation. The plan describes the scope of the ESD control program; describes the tasks, activities, and procedures necessary to protect ESD sensitive items; identifies organizations responsible for the tasks and activities; and lists directive or guidance documents used in the ESD control program. The plan also describes ESD control requirements imposed on subcontractors and suppliers by prime contractors. The final element of the plan is a listing of the specific ESD protective tools, materials, and equipment used in the ESD control program. The major element in a properly structured technically effective ESD control program plan is the assessment of the ESD susceptibility of the parts and their required protection levels. The selection of specific ESD control procedures or materials is at the option of the plan preparer. MIL-STD-1686 does not mandate or preclude the use of any appropriate procedures or materials.

5.2 Classification of ESDS parts, assemblies and equipment. ESDS parts, assemblies, and equipment are classified as class 1, 2, or 3 in accordance with MIL-STD-1686. MIL-STD-1686 requires that the ESD control program normally encompass only class 1 and 2 parts, assemblies and equipment. For mission critical or essential equipment, as designated by the contracting activity, class 3 parts, assemblies and equipment shall be included in the ESD control program in accordance with MIL-STD-1686. Classes 1, 2, and 3 of MIL-STD-1686 may be optionally subdivided to more selectively classify ESDS parts, assemblies and equipment. Subclassification voltage ranges are discretionary, but they must correlate to the sensitivity classification voltages in accordance with MIL-STD-1686.

5.2.1 Part classification. The sequence for parts ESD sensitivity classification in accordance with MIL-STD-1686 is predicated upon the requirement to eliminate duplicative non-cost effective testing where feasible. MIL-STD-883 Method 3015, commonly referred to as the Human Body Model (HBM), is the military ESD test method for microelectronics (microcircuits) and is referenced in MIL-M-38510, MIL-H-38534, MIL-I-38535, MIL-BUL-103, and MIL-STD-1686. MIL-STD-750 Method 1020 is the military HBM ESD test method for semiconductor (discrete) devices. These documents provide a coordinated requirement for ESD

testing. ESD sensitivity data contained in the MIL-M-38510 Qualified Products List (QPL), the MIL-H-38534/MIL-I-38535 Qualified Manufacturer Listing (QML), or the Reliability Analysis Center ESD sensitive item list (ESDSIL) will provide the definitive microcircuit classification data required for ESD control program implementation. In those cases where classification testing is not cost effective, parts may be classified in accordance with MIL-STD-1686, appendix B. Where definitive test data is required for parts not included in the appropriate QPL/QML, Military Bulletin, or VZAP-91, MIL-STD-1686 appendix A is used. It should be noted that when the Reliability Analysis Center's VZAP-91 data base is used for classification, the test circuit should be in conformance with the MIL-STD-1686 appendix A test circuit or a comparable test method approved by the contracting activity. MIL-STD-1686 provides another cost effective classification method when ESD sensitivity levels are specified in applicable military part specifications. When parts ESD sensitivity testing is performed in accordance with MIL-STD-1686, classification test data should be as specified.

5.2.2 Assembly and equipment classification. Assembly and equipment ESD sensitivity classification are in accordance with the most sensitive class of part used in the assembly or equipment. When assemblies or equipment incorporate protective circuitry to meet the design protection requirements of MIL-STD-1686, the assembly or equipment is classified at the design hardened voltage protection level (see 5.3 below for additional guidance). Classification of assemblies or equipment incorporating protective methods to meet the MIL-STD-1686 2,000 or 4,000 volt design hardening requirement must be based upon approved and justified analytical techniques or actual test.

5.3 Design protection. MIL-STD-1686 design protection requirements for assemblies (2,000 volts) and equipment (4,000 volts) specifically relate to the protection (design hardening) at the points of external connection to the assembly or equipment (inputs, outputs and interface connection points). Since it is not possible to provide universal definitions of the terms "assembly" or "equipment," guidance should be obtained from the acquiring activity to define these terms for a specific acquisition.

5.3.1 Protection of parts and assemblies. When class 1 parts must be used, MIL-STD-1686 requires design protection to reduce the ESD sensitivity of the assembly external connection points to greater than 2,000 volts. Assemblies utilizing protective circuitry to meet the 2,000 volt assembly requirement of MIL-STD-1686 may still contain parts sensitive to damage at voltage levels less than 2,000 volts. In these cases, the assembly would be classified as 2,000 volts (class 2). Part level classification, of the parts used in the assembly, will be indicative of the part's actual classification.

5.3.2 Protection of equipment. Equipment meeting the design hardening requirement (4,000 volts) of MIL-STD-1686 at the points of external connection to the equipment (inputs, outputs and interface connection points) may still

contain assemblies and parts sensitive to damage at voltages less than 4,000 volts. In these cases, the equipment would be classified as 4,000 volts (class 3). Part level classification, of the parts used in the equipment, will be indicative of the part's actual classification.

5.4 Protected areas. An ESD protected area consists of the materials, equipment, and procedures required to control or minimize electrostatic charges (static voltage levels). The fundamental ESD protected area concept is to limit static voltage levels below the damage threshold of the most sensitive ESDS parts, assemblies and equipment handled therein. Considerations in the design of ESD protected areas are the requirements for adequate grounding procedures, personnel electrical safety, and the development of handling procedures (see 5.5). ESD protected areas are required when handling ESDS parts, assemblies and equipment outside of their ESD protective covering or packaging. When ESDS parts, assemblies and equipment must be handled outside of protected areas without protective covering or packaging, detailed ESD protective handling procedures are required.

5.4.1 Related design factors. Related to the design of protected areas are factors such as minimizing static charges generated by personnel clothing, hair, and movement; the need to designate and clearly identify protected areas; and the essential requirement to address personnel safety requirements.

5.5 Handling procedures. Complementing ESD protected area requirements are the requirements for detailed handling procedure for ESDS parts, assemblies and equipment in accordance with MIL-STD-1686. Technically adequate handling procedures are directly related to the level of protection provided by the protected area. Handling procedures must be comprehensive and address the entire range of potential situations and physical locations where ESDS items will be handled. Practically, the handling procedures must address the concept of handling in both fully protected areas and unprotected areas. The detail required in the handling procedures increases as the level of protection provided by the protected area decreases. Documented handling procedures may be required by the contract or purchase order (see MIL-STD-1686, 6.2) and are prepared in accordance with DID DI-RELI-80671A when required.

5.6 Protective covering. The MIL-STD-1686 protective covering requirement is closely linked to, and complements the requirements for protected areas and handling procedures. ESDS sensitive parts, assemblies and equipment require continuous ESD controls and protection. This consists of the ESD controls and protection provided by the protected area requirement or the requirement for protective covering when not being worked on or handled outside of protective areas. Selected ESD protective covering consists of the materials (tote boxes, containers, bags, pouches, rails, or boxes) that provide adequate levels of ESD protection based upon the sensitivity of the parts, assemblies

and equipment in accordance with MIL-STD-1686 section 5.2. Selected protective covering materials may be the same materials required for packaging or preparation for delivery, supplementary reusable materials, or one time use materials.

5.7 Training. Recurrent ESD training for personnel is an integral and critical part of an ESD control program. Recurrent ESD training includes initial and follow-on training required to reinforce program requirements and modification based upon lessons-learned. New evolutionary concepts and correction of deficiencies identified during reviews and audits should also be part of the training process. The training requirements are developed in conjunction with the handling procedures for ESDS parts, assemblies and equipment required by MIL-STD-1686.

5.8 Marking of hardware. The MIL-STD-1686 requirement for marking of hardware pertains to those ESDS parts, assemblies and equipment which have not been marked in accordance with an applicable (otherwise specified) military specification or standard. If there is an applicable specification or standard, the item of hardware (part, assembly or equipment) should be marked in accordance with the requirements of that specification or standard. However, if no applicable specification or standard applies, and no other marking requirements have been specified, marking shall be in accordance with MIL-STD-1686, 5.8, marking of hardware. MIL-STD-1686 specifies that ESDS parts shall be marked with the EIA RS-471 symbol.

5.8.1 ESDS assemblies. MIL-STD-1686, 5.8.2 requires that assemblies be marked with the EIA RS-471 symbol. The location of the symbol must be in a position readily visible to personnel when the assembly is incorporated in its next higher assembly. The exact location is left to the discretion of the contractor. Additional options have been provided for those instances where the physical size or orientation of the assembly precludes compliance with this MIL-STD-1686 requirement, including the option of developing alternative marking procedures.

5.8.2 Equipment. MIL-STD-1686 states the requirement for marking of equipment containing ESDS parts and assemblies. This section also requires the use of the EIA RS-471 symbol. In addition, the caution statement shown in MIL-STD-1686 shall be placed adjacent to the symbol. The exact location of the symbol and caution statement is left to the discretion of the contractor but the location must meet the basic equipment marking requirement as specified in MIL-STD-1686.

5.8.3 External equipment terminals. MIL-STD-1686 contains the requirement for the marking of external equipment terminals connected internally to ESDS parts and assemblies within the equipment. The EIA RS-471 symbol must be used, and it must be located adjacent to the external terminals.

5.9 Documentation. Deliverable documentation, as discussed in MIL-STD-1686 refers to deliverable documentation required by the contract, delivery order, or purchase order invoking MIL-STD-1686. This deliverable documentation is specified in the contract data requirements list (CDRL), DD Form 1423. In the case of drawings prepared in accordance with DOD-STD-100 or Technical Data Packages in accordance with MIL-T-31000, or MIL-T-47500, as applicable, ESD requirements and symbol locations shall be specified or referenced. Examples of deliverable documentation include, but are not limited to, technical data packages, technical manuals, provisioning technical documentation, logistics support analysis data, and drawings. MIL-STD-1686 requires that deliverable documentation identify class 1, 2, and, when specified mission critical or essential class 3 parts, assemblies, equipment, and the connectors, test points, and terminals connected to ESDS parts and assemblies collectively as ESDS. This means that the exact classification (that is, class 1, 2, or 3) is not required; however, exact classification data may be used by the contractor if desired. A collective identification of parts, assemblies, equipment, connectors, test points, and terminals as ESDS is required. MIL-STD-1686 also requires that the deliverable documentation include or refer to documented ESD protective procedures. MIL-STD-1686 allows the contractor the option of identifying ESDS parts, assemblies, or equipment collectively as ESDS, or the use of exact classifications (class 1, 2 and, when required, class 3) in nondeliverable documentation used for ESD control program implementation. Additionally, nondeliverable documentation may optionally include or refer to documented ESD protective procedures.

5.10 Packaging. Normally contracts and delivery or purchase orders specify exact packaging requirements using MIL-STD-2073 packaging requirement codes (PRCs). When packaging requirements are not otherwise specified, ESD protective packaging shall be as specified in MIL-E-17555 in accordance with MIL-STD-1686. MIL-STD-1686 contains the additional requirement that ESD protective caps shall be used on equipment external connectors connected to ESDS parts and assemblies within the equipment. The MIL-STD-1686 requirement for protective caps complements and is in consonance with MIL-STD-454, requirement 10 for the protection of unmated connectors with metal or plastic caps during maintenance, storage and shipment.

5.11 Quality assurance requirements. The quality assurance requirements of MIL-STD-1686 indicate the importance of incorporating ESD control program requirements in Total Quality Management and quality assurance efforts, including those performed at subcontractors, suppliers, and vendors. Quality assurance evaluates conformance with MIL-STD-1686 requirements and the approved ESD control program plan.

5.12 Formal reviews and audits. Scheduled design, program reviews, and audits, such as those required by MIL-STD-1521, shall be used to assess compliance with MIL-STD-1686 and the approved ESD control program plan. These reviews will assess the information required in MIL-STD-1686 to determine the

acceptability of design decisions, ESD controls, procedures and program progress.

5.13 Failure analysis. In accordance with MIL-STD-1686, the intent of failure analysis is to consider all causes of failures. A comprehensive failure analysis program will include ESD failure mechanisms as part of the analysis process. When failures have been attributed to ESD, this data should be used as a basis for assessing the effectiveness of the ESD control program and the determination of corrective action requirements.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This document provides guidance information to assist the user in designing and implementing an ESD control program in accordance with MIL-STD-1686B requirements. The supplementary technical data provided in appendices A through L is provided as information only for reference. Due to the nature of the changes in MIL-STD-1686B this handbook is intended for use only with MIL-STD-1686B. For those contracts incorporating DOD-STD-1686 of 2 May 1980, the companion document is DOD-HDBK-263 of 2 May 1980. For those contracts incorporating MIL-STD-1686A of 8 August 1988, the companion document is MIL-HDBK-263A of 22 February 1991.

6.2 Issue of DODISS. When this handbook is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1, and 2.2).

6.3 Subject term (key word) listing.

Electrostatic protection
Electrostatic discharge sensitive (ESDS)
ESD control program
Metal oxide semiconductors
Semiconductor devices
Static electricity
Triboelectric effect

6.4 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - ER
Navy - SH
Air Force - 17

Preparing activity:
Navy - SH
(Project RELI-0067)

Review Activities:
  Army - AT, CR, MI, AR, GL, SM
  Navy - AS, EC, OS, SA
  Air Force - 11, 15, 19, 99

User Activities:
  Navy - MC
  Air Force - 69
  NASA/NPPO